IMPROVING COGNITIVE INDEPENDENCE OF DEMENTIA PATIENTS USING MACHINE LEARNING ENABLE MOBILE APPLICATION

Project Id: 2023-081

Madhubhashini A.D.P.

IT20174576

B.Sc. (Hons) Degree in Information Technology

(Specialization in Information Technology)

Department of Information Technology

Sri Lanka Institute of Information Technology

Sri Lanka

September 2023

IMPROVING COGNITIVE INDEPENDENCE OF DEMENTIA PATIENTS BY PROVIDING A FACE RECOGNITION SYSTEM TO IDENTIFY THEIR LOVED ONES AND RELATIVES

Project Id: 2022-081

Madhubhashini A.D.P.

IT20174576

The dissertation was submitted in partial fulfilment of the requirements for the B.Sc. Special Honors degree in Information Technology (Specialization in Information Technology)

Department of Information Technology

Sri Lanka Institute of Information Technology

Sri Lanka

September 2023

DECLARATION

I declare that this is my own work, and this thesis does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any other university or Institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text.

Name	Student ID	Signature
Madhubhashini A.D.P.	IT20174576	

The above candidate is carrying out research for the undergraduate Dissertation under my supervision.

Signature of the supervisor Date

……. …….……

(Ms. Geethanjali Wimalarathne)

ABSTRACT

Dementia is marked by severe mental decline, which may be expressed as challenges in performing Activities of Daily Living and Instrumental Activities of Daily Living. This results in a vulnerable population of people who do not have proper support (National Collaborating Centre for Mental Health, 2007) [9].

It causes patients to have trouble recalling the identities of familiar faces. In addition, patients often struggle to communicate with others around them. The objective of this research is to propose a smart solution based on a facial recognition system to help dementia patients recognize their loved ones and address the challenges faced due to short-term memory impairment. To address this, our application utilizes facial recognition technology in conjunction with a description of the person photographed and the smartphone camera.

This enables the patient to identify their loved ones. Additionally, we hope to present the patient with memories or videos of the person in the photo. In this proposed study, we implemented a convolutional neural network(CNN), deep Neural network-based facial recognition system integrated with a smartphone camera and person description feature. The application could be a useful tool for patients to identify their loved ones and enhance their interaction with the people surrounding them. Further studies could explore the effectiveness of the proposed application in clinical settings

Keywords— Neural Network, Dementia, short-term memory impairment, face recognition technology, Cognitive disability

ACKNOWLEDGEMENT

First and foremost, I want to convey my heartfelt thanks to Miss Geethanjali Wimalarathne, my supervisor, for all her encouragement, advice, and support during the research process, as well as the insightful remarks she provided to help the research project succeed. Aside from my supervisor, I'd like to thank Ms. Wishalya Thissera, the co-supervisor of this research project, for always being willing to help. This research required the perseverance of many people. Their invaluable input and time supported me in achieving ideal accomplishment over the term of my educational attempt. In addition, I'd like to thank the CDAP team for assisting us in successfully completing our project. Then, I'd like to express my heartfelt appreciation to my friends for their unfailing support during this endeavor. In addition, I want to express my gratitude to my parents for their constant support and encouragement. A special thanks to the other researchers who collaborated with me to make this research more effective and successful.

TABLE OF CONTENT

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

Abbreviation	**Description**
CNN	*Convolutional Neural Network*
A*WS*	A*mazen web services*
S*3*	S*imple Storage Services*
E*CR*	E*lastic Container Registry*
W*HO*	W*orld Health Organization*
A*PI*	A*pplication Programming Interface*
O*S*	*Operating System*

1. INTRODUCTION

Short-term memory impairment stands out as a prominent challenge faced by individuals with dementia, hindering their ability to recognize and identify their family members, friends, and other loved ones, which directly affects their independence, making it challenging for them to recognize familiar faces, including their own and those of their friends and relatives [3] [4]. This inability to connect with familiar faces often leads to feelings of frustration, anxiety, and emotional distress, not only for individuals with dementia but also for their family members. Consequently, the mental well-being and quality of life of both parties are significantly affected. When studying literature points, various tools have been built to recognize faces, and several assistive tools have also been implemented for normal people.

Most of the existing solutions are implemented for a limited audience and lack functions. Non-pharmacological management of dementia puts a burden on those who are taking care of a patient [5]. To address this issue, the development of a face recognition mechanism for detecting and identifying familiar faces of dementia patients has emerged as a potential solution. Most existing facial recognition software is designed for use by caretakers, giving them aid in keeping a close eye on their dementia patients.

The uniqueness of our solution and others is that it was developed with the input of people living with dementia, considering their preferences, skills, and limitations. By creating a real-time face recognition system, researchers aim to enhance the quality of life and independence of individuals with dementia. Despite the growing body of literature on dementia care, studies focusing specifically on real-time face recognition mechanisms for detecting familiar faces among dementia patients remain scarce.

Thus, there is a need for further research in this area to explore the effectiveness and feasibility of such mechanisms in improving the lives of individuals with dementia. Furthermore, our solution goes beyond just face recognition and adds value by

incorporating additional features that are beneficial to dementia patients. For example, instead of providing a brief introduction of the person (name and the relationship between the patient), it may include prompts for memory slides regarding the captured person after detecting the person's face. These features are specifically tailored to address the needs of dementia patients, make them more interactive, and promote their well-being, and independence.

1.1. Background & Literature Survey

Dementia individuals are people who have experienced a significant loss in their cognitive and memory functions, which causes significant difficulties in their day-to-day lives and activities. It is a degenerative disorder that has a gradual impact on a person's thinking, memory, conduct, and capacity to carry out activities of daily living.

The World Health Organization estimates that there are 35.6 million people living with dementia, and that number rises by 7.7 million per year. This figure is expected to double by the year 2030 and triple by the year 2050 [1]. Dementia has significant physical, psychological, social, and economic effects on caretakers, families, and community due to the decline in memory, cognition, and ability to carry out everyday tasks [1].

Many kinds of research have shown that incorporating touchscreen technology into cognitive stimulation therapy can improve cognitive function in older people with dementia[2].

As a consequence of advancements in medicine and technology, the geriatric population and life expectancy are both increasing. It is anticipated that the amount of individuals with Alzheimer's disease will nearly double in every 20 years [1].

Patients with dementia frequently experience short-term memory impairment, which is directly affect their independence, making it challenging for them to recognize familiar faces, including their own and those of their friends and relatives [3],[4]. In this situation, patients need to get support from a third party to recall their memory. This situation can have a profound emotional impact on both dementia patients and their relatives and other loved ones.

With the purpose of creating an assistive tool for identifying familiar faces, we conducted a survey of random 50 people in the society. According to the survey that we conduct, the majority of people respond about the emotional impact. (Figure 1.0). This is one of the major problems that have for dementia patients and their loved ones.

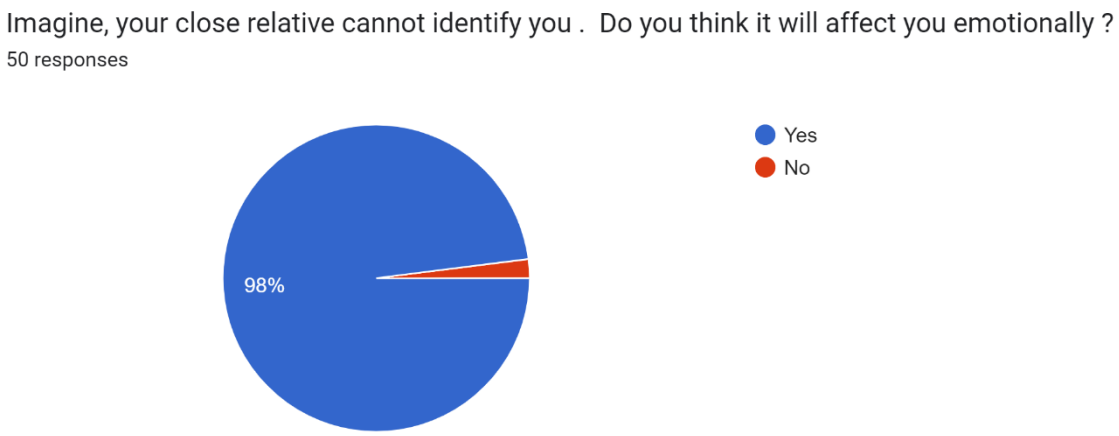


Figure.1.0: Survey results that about the emotional impact

In addition to that, the family also takes on the role of primary caregiver, which is frequently an emotionally challenging and very stressful job. One-third of individuals with depressive symptoms were family caretakers.. Initially, it can be quite difficult for the distant caregiver to continuously monitor patients as not everyone is living closer by [5]

According to medical data, in Asian countries, most dementia patients live alone, without any caregivers. Therefore, they cannot always get a help from third parties to maintain their day-to-day lives. As the people who know the value of independence, we want to improve their quality of life and make them more independent.

As shown in figure 1.1 our survey shows that the majority of participants considered the importance of identifying their loved ones and familiar faces to maintain an independent life.

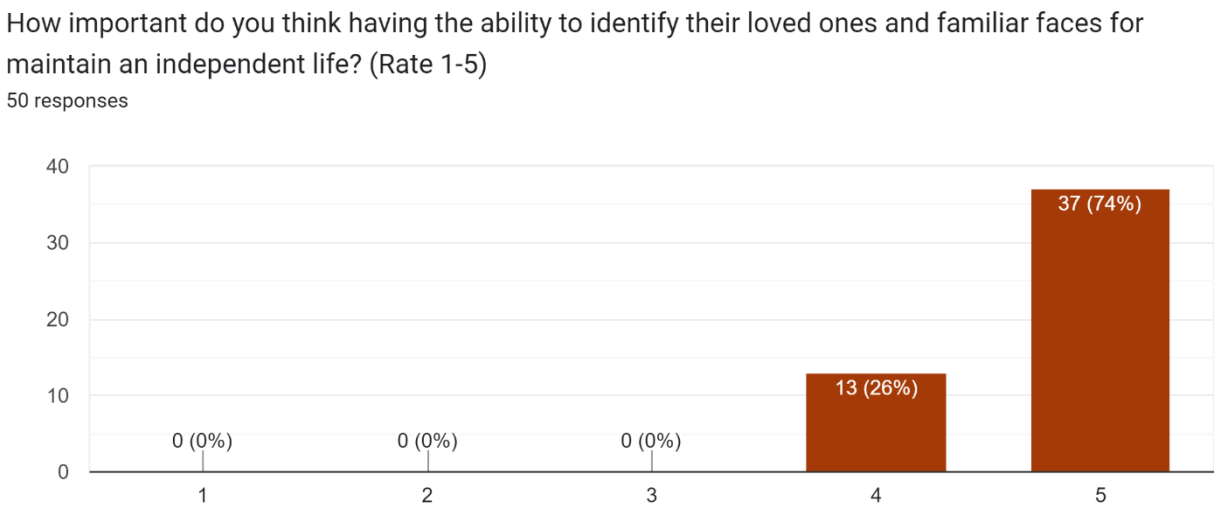


Figure 1.1: The importance of the ability to identify faces

Even though there are traditional solutions like having a caregiver to aid these kinds of individuals to recall their memory, since not all caregivers live in close proximity, remote monitoring may be a challenge[5]. As shown in figure 1.2 our survey shows that most people in society think all dementia patients haven't the ability to keep a caregiver for their day to lives.

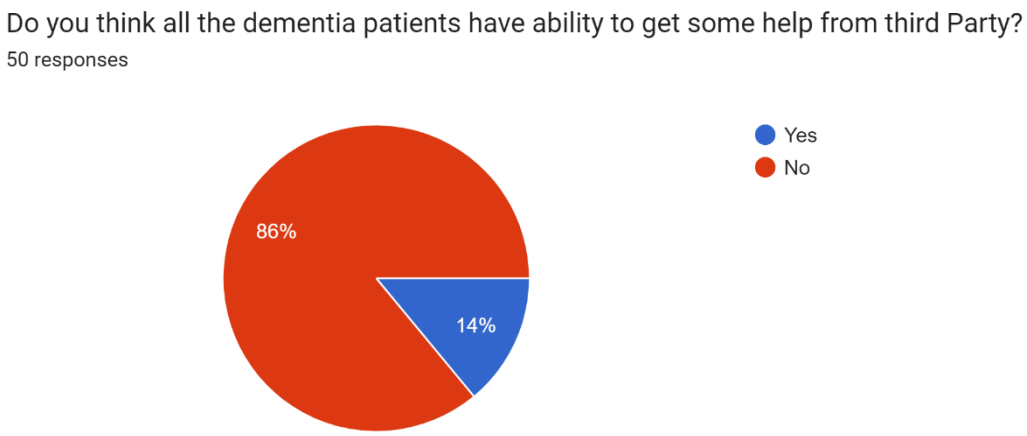


Figure 1.2: Survey results that regarding the help of third party

According to the Sri Lankan hospital data, most mild and moderate-level dementia patients spend their time alone. And the other main considerable thing is the cost of caring for a patient with dementia is high. Seven out of ten people with this condition live at home, where their families pay for the majority (75%) of their maintenance. As a solution to this issue, we ask what the effective and easy ways are to avoid those difficulties. Then we received some answers as shown in figure 1.3. The majority of society agree with making an assistive tool for dementia patients to identify their familiar faces is the most efficient and effective way to improve their quality of life.

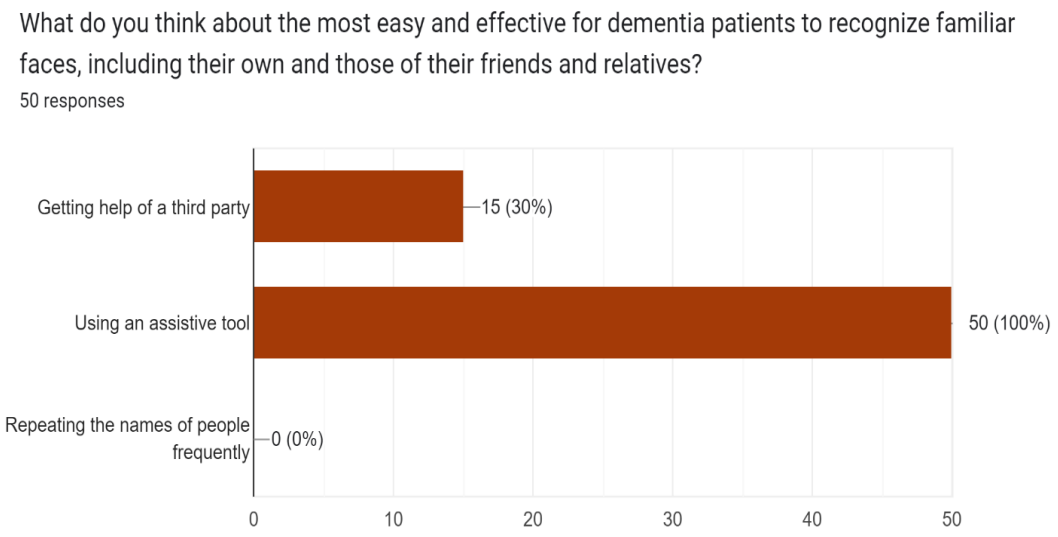


Figure 1.3: Survey results that display the effective and easy way to recognize familiar faces of dementia patients

1.2. Research Gap

Comparing recent research on facial recognition applications and dementia patients there is very lack of research exploring the effective and efficient system for directly targeting the dementia patients. When studying literature points, various tools have been built to recognize faces, and several assistive tools have also been implemented for normal people. Most of the existing solutions are implemented for a limited audience and lack functions.

Caregiving is a non-pharmacological treatment for dementia patients. Caregivers are frequently investigating the patients' behavior. Providing non-pharmacological care for dementia patients places a significant responsibility on the caregivers.[5].
Most existing facial recognition software is designed for use by caretakers, giving them aid in keeping a close eye on their dementia patients. The uniqueness of our solution and others is that it was developed with the input of people living with dementia, considering their preferences, skills, and limitations.

Knowing that people with dementia have cognitive impairments, we designed facial recognition software specifically for them. The interface and functionality have been developed with individuals with dementia in mind, making them easy to use and accessible. The application sets a priority on the user's capacity to identify familiar faces, which in turn provides the individual with a feeling of comfort, safety, autonomy, and independence.

As shown in figure 1.4 most people suggested us, to create an assistive tool with a facility of memory-recalling option of the captured person.

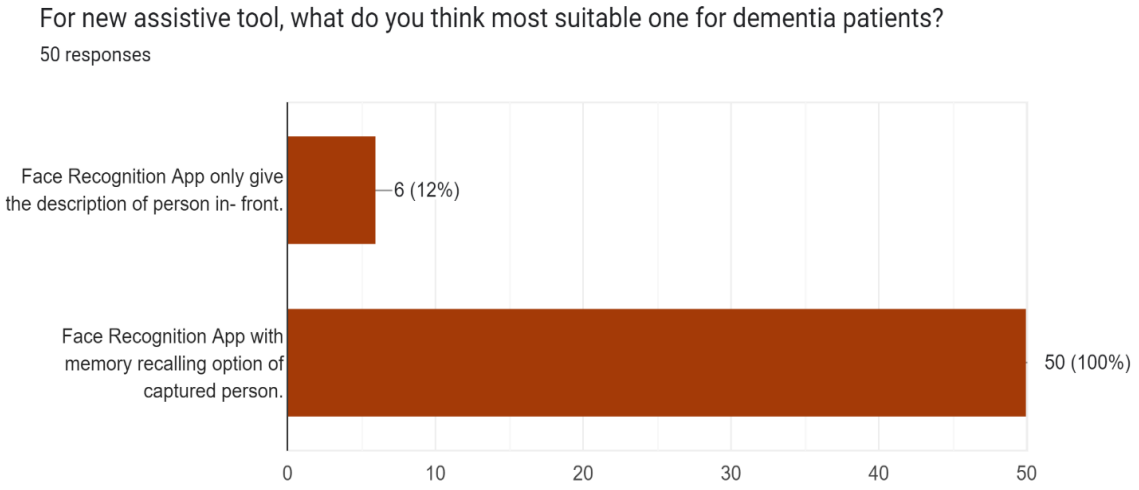


Figure 1.4: Survey results that display the most suitable assistive tool for dementia patients

Furthermore, our solution goes beyond just face recognition and adds value by incorporating additional features that are beneficial to dementia patients. For example, instead of providing a brief introduction of the person (name and the relationship between the patient), it may include prompts for memory slides regarding the captured person after detecting the person's face. These features are specifically tailored to address the needs of dementia patients, make them more interactive, promoting their well-being, and independence.

Face detection can be done in many ways, but when it comes to dementia, we must think a lot about the user interface also. We must use large icons and large fonts for the minimal distraction and ease of patients. Furthermore, many existing face-detection applications are not specifically created for dementia patients [6](Research A)[7]. People suggest us to add some features [figure 1.5] from their perspective to the proposed face recognition app for make it more effective to improve the effectiveness and efficiency of that application.

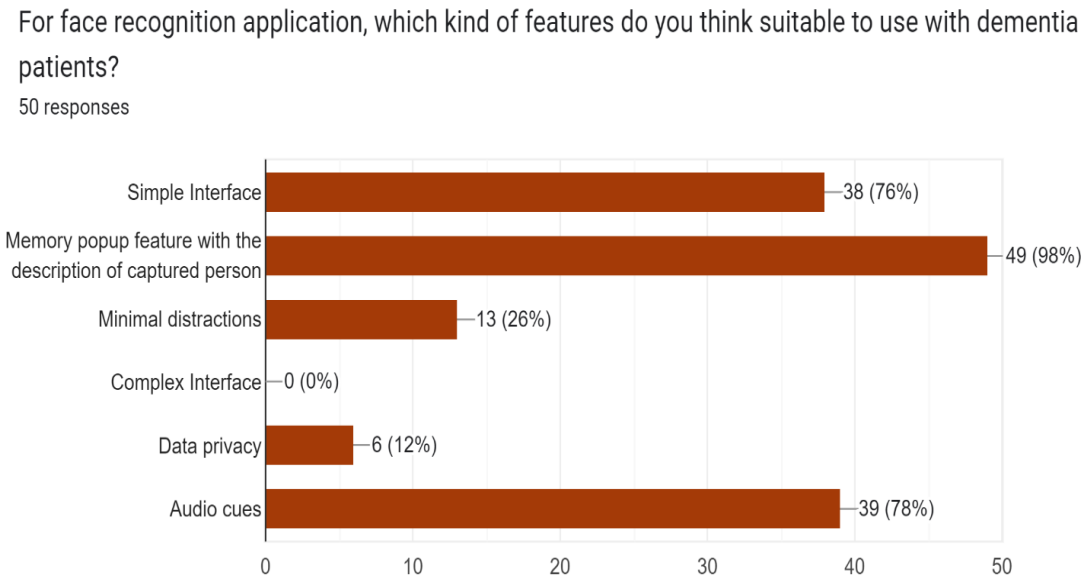


Figure 1.5: Survey Results that display the suitable features for the proposed app

We found some face recognition applications for dementia patients, but they only display the description of the person who is captured in the phone camera[4](Research B). Some existing applications are not real-time face recognition features[3](Research C) [14] .

Furthermore. The results of the survey indicate that most of the participants think that the face recognition application will be more effective in assisting with memory recall function. Because it helps patients to recall their memory with that person and additionally it affects their entertainment also. And we found out dementia patients are interested in visual screening. The results that we are get, shown in figure 1.6.

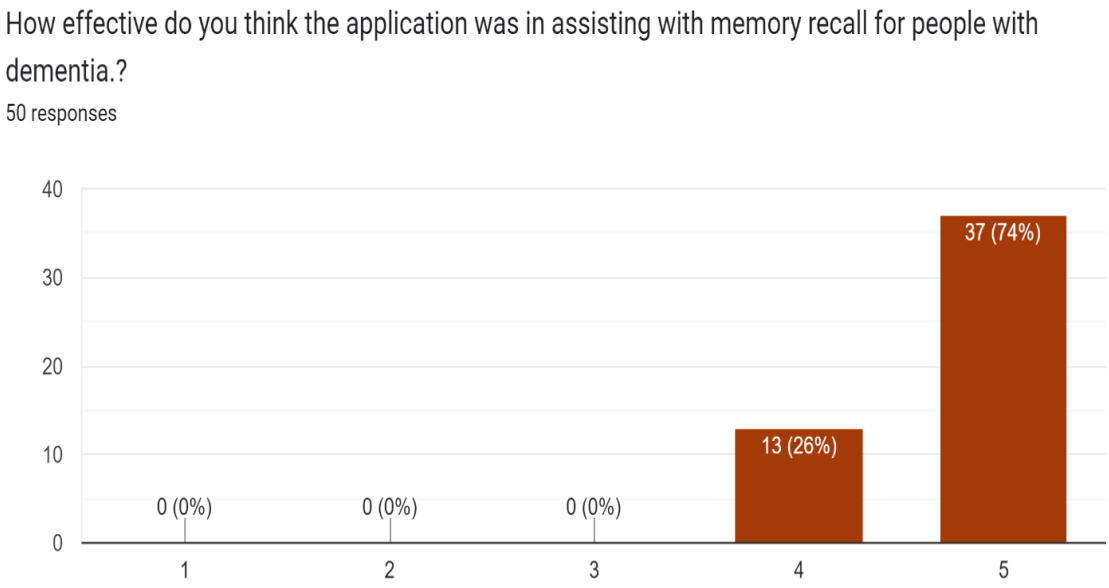


Figure 1.6: Survey results that display the effectiveness of memory recall interactive option

And furthermore, when comparing existing researches and other solutions(Research A, B) they only provide the name and the relationship of that captured person.
Most of the dementia patients are elderly people, therefore they may have some difficulties reading the content on the screen.

To overcome with this problem, in our proposed solution also provide that feature with a voice output to hear the content screening in addition to see the details on the screen.
Our solution also emphasizes the importance of maintaining the dignity and privacy of dementia patients.

According to our survey, people are not aware of the existence of face recognition apps with memory popup features for dementia patients. Shown in figure 1.6

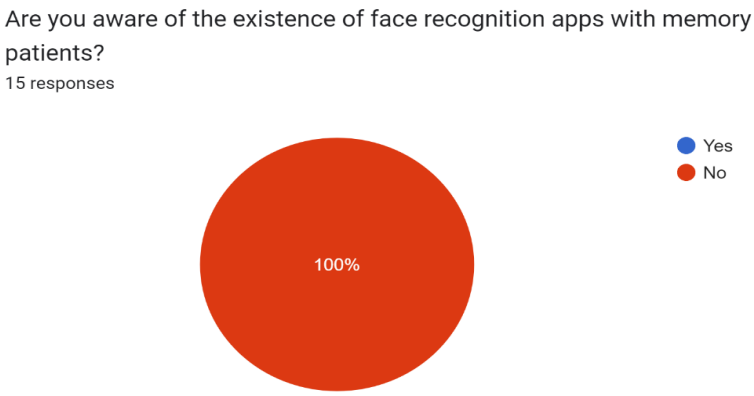


Figure 1.7: Survey results that display the existence of memory popup face recognition App

In below mentioned table display the summary of the comparison of the existing solutions and the proposed solution. By reviewing the table below, you can come with an idea that what are the novelties of the proposed solution.

Table 1.1: Research gap for document segmentation and classification with existing system

Features	**Research A**	**Research B**	**Research C**	**Solution**
A real-time image-capturing option using the smartphone camera	X	√	X	√
Screening the person's Information	√	√	X	√
Use a text-to-speech module to hear the information	X	√	X	√
Special user interface creation for dementia patients	X	X	√	√
Use object recognition mechanism to filter a memory, related to the captured person	X	X	X	√

1.3. Research Problem

Dementia is defined as a general cognitive impairment, which may be expressed as challenges in engaging Activities of Daily Living and Instrumental Activities of Daily Living. (National Collaborating Centre for Mental Health, 2007) [9]. When we consider the existing research solutions and the dementia patients there is a lack of research exploring the effective and efficient system for targeting the dementia patients. Although most caregivers live with the patients, about 15% act as long-distance caregivers, residing at more than one hour's drive away. This kind of situation makes constant monitoring of patients extremely difficult for these remote caregivers[5]. Another problem is caregivers are very costly these days.

According to our external supervisor(neurologist) , In Sri Lanka majority of dementia patients live alone without any caregiver. Therefore, every time, dementia patients can't get a third-party assistant to identify people [5].

And the most considerable thing is the inability of identifying people can have a profound emotional impact on both dementia patients and their family members. According to the survey that we conducted, the majority of the people agree with the above statement(Figure 1.7). Not only that but also, dementia patients may be socially isolated in such kind of situation. And that leads to feelings of frustration, fear, and anxiety.
Therefore, for the purpose of improving their quality of life and making their lives more independent, we are developing a mobile application to address the needs of individuals with mild to moderate dementia who experience cognitive difficulties. The result will be a more intuitive and efficient human-computer interaction, making our application a valuable tool for enhancing the quality of life for those with dementia.

According to the survey conducted, figure 1.8 depicts that many people think that face recognition applications are helpful for dementia patients. Figure 1.9 shows the most

affected aspects of face recognition application for dementia patients.

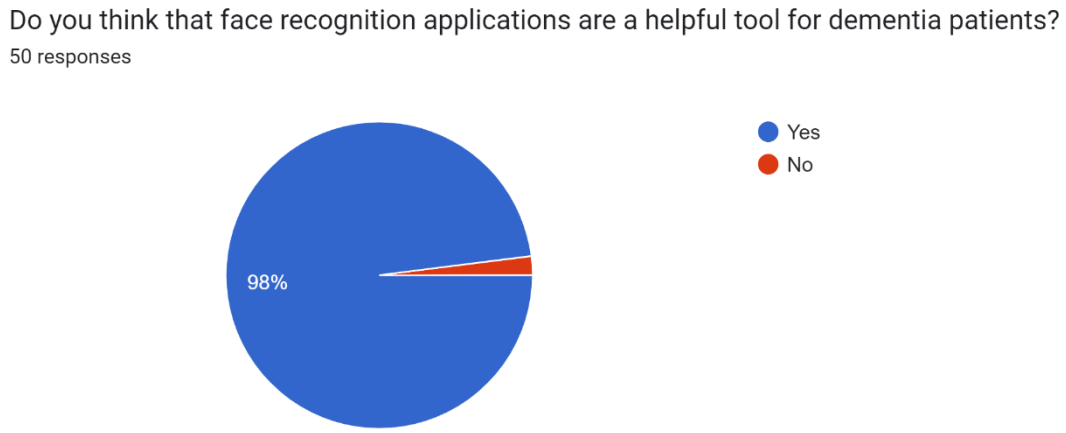


Figure 1.8: Survey results that display the importance of face recognition application helpful for dementia patients

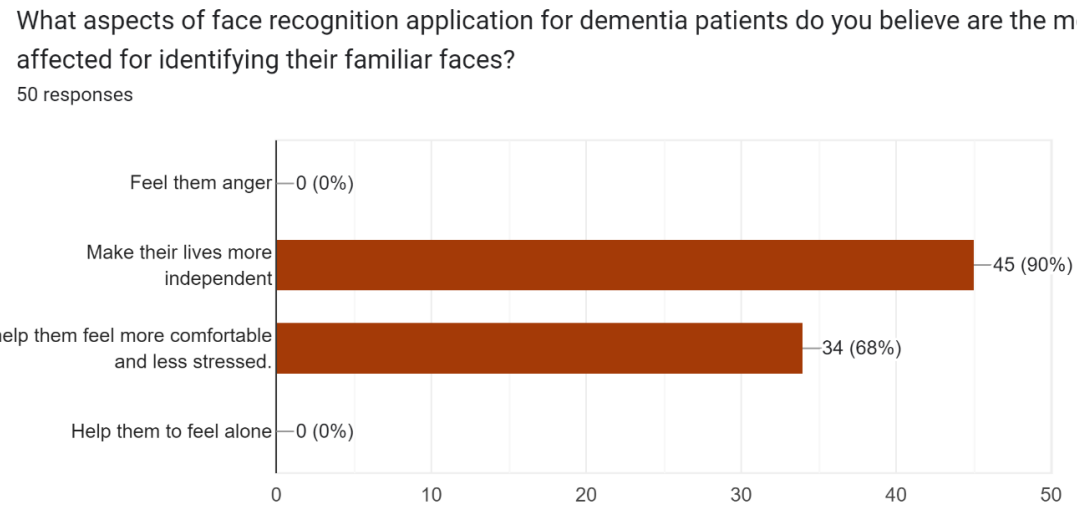


Figure 1.9: Survey results that display the most affected aspects of face recognition application for dementia patients.

2. RESEARCH OBJECTIVES

2.1. Main Objective of the solutions.

The core objective of this research is to develop an efficient solution capable of identifying a patient's loved ones and relatives through face recognition in a manner that ensures the patient's independence. This component's input will be the person's face, and its output will be the person's details.

2.2. Sub Objectives

In addition to the main objectives, there are some specific objectives related to the implementation

- Developing the proper algorithm for detecting familiar faces and providing the user with information about the person.
- Creating a recollection of that individual or a slideshow of photos with that person for the patient to watch. Additionally, developing access to an album where he can see memory slideshows whenever he wants.
- Face detection: This involves locating faces in an image or video.
- Feature extraction: This involves extracting facial features, such as the eyes, nose, mouth, and shape of the face, to create a unique facial representation or feature vector.
- Face comparison: This involves comparing two or more facial representations to determine if they belong to the same person or not.
- Face verification: This involves confirming the identity of an individual by comparing their facial features to those stored in a database.
- Face recognition: This involves identifying an individual by matching their facial features to a database of known individuals.
- Implement a text-speech library to get the voice output of the displayed content.

3. METHODOLOGY

3.1. Methodology

Developing software to assist dementia patients in finding relations by capturing images using face recognition technology is a promising approach to improving their quality of life. The created system would use Neural Network Algorithms to detect and match the faces of individuals in the patient's social gallery with previously stored images and records.

To develop this software, several core functionalities would need to be implemented, including an image recognition system based on machine learning techniques, a database for storing images and personal information, and a user interface that would enable patients to interact with the application with a minimal distraction. Additionally, the system should incorporate text-to-speech library and other assistive technologies to facilitate communication with the patient.

To implement the image recognition system, neural networks (NNs) can be used. These networks have demonstrated excellent performance in facial recognition tasks, with some models achieving near-human levels of accuracy [8],[9] [10].

Once an image is captured, the system would use the neural network to compare it to previously stored images and retrieve all relevant information associated with the individual.

Convolutional neural networks (CNNs) are one of the machine learning methods that are used to find faces in images. The face detection algorithm looks through the image and finds areas where faces are probably to be present. Once faces are detected, the model extracts facial features from the detected faces. It uses a deep neural network to generate a numerical representation, called face encoding or face embedding, for each face. This encoding captures unique characteristics and patterns of the face. To perform face recognition, the model compares the face encodings of the detected faces with the encodings of known faces stored in a database or a list. It computes the similarity between

the face encodings using distance metrics such as Euclidean distance. A threshold value is usually set to determine whether two face encodings are considered a match. Based on the computed similarities, the system can identify known faces by finding the closest match(es) to the detected face(s) in the list of known faces. It can also determine if a detected face is unknown if it does not closely match any known face.

The face recognition application in this research uses an AWS S3 bucket to store the images of faces that are used to train and test the face recognition model. This makes it ideal for storing the large number of images that are typically used to train and test face recognition models. AWS S3 is a highly scalable, secure, and durable object storage service that offers a simple web interface to store and retrieve objects. By utilizing AWS S3, which automatically replicates data across several data centers and provides built-in redundancy, we were able to assure the dependability and longevity of our data. The low risk of data loss and high availability provided by this redundancy makes it the perfect option for mission-critical applications like face recognition.
AWS S3, enabling us to quickly upload, download, and manage photographs within the S3 bucket straight from our application.

In terms of security, AWS S3 provided us with various options to protect our data, such as server-side encryption and access control policies. This ensured that our sensitive image data remained confidential and was accessible only by authorized users and services.

The user interface designing should be simple and intuitive for dementia patients [11], [12] for improve the human computer interaction of proposed solution. The interface should include features such as voice output, large fonts, large icons , and simple navigation [11]. Since we are focusing on the dementia patients as the audience of this application , it should be a minimal distractive application.

To evaluate the effectiveness of the system, a randomized trial can be conducted. In this trial, participants would be assigned to the experimental group, which would use the

software application. The trial would measure the changes in cognitive function and quality of life in both groups over a specified period.

In conclusion, the proposed system has the ability to significantly improve the quality of life and independence of dementia patients by providing a simple and intuitive way to access information about their social network.

3.1.1. High Level System Overview Diagram

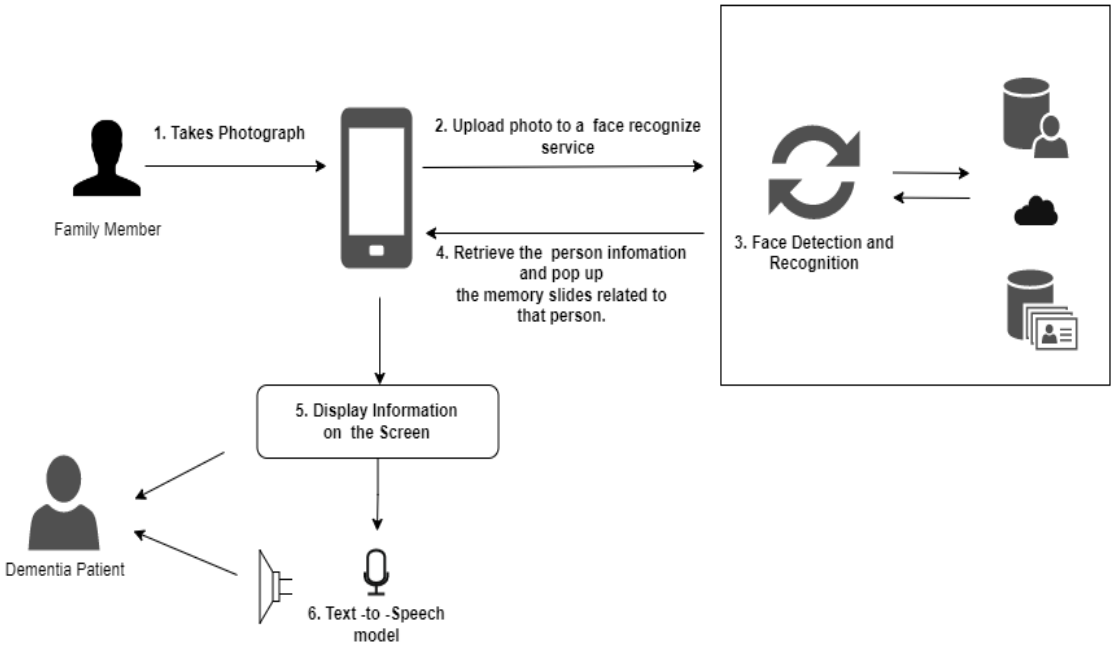


Figure 3.1: System Overview Diagram

Figure 3.1 shown the high-level view of the face recognition system. The caregiver can add the relatives and other loved ones of the patient to the system. Therefore, when patient captures the photograph of the person who wants to recognize, the name and the relationship of the person. Also, it gives the voice output of the displayed text messages. Below I added the architecture of the system.(Figure 3.2 System Architecture).

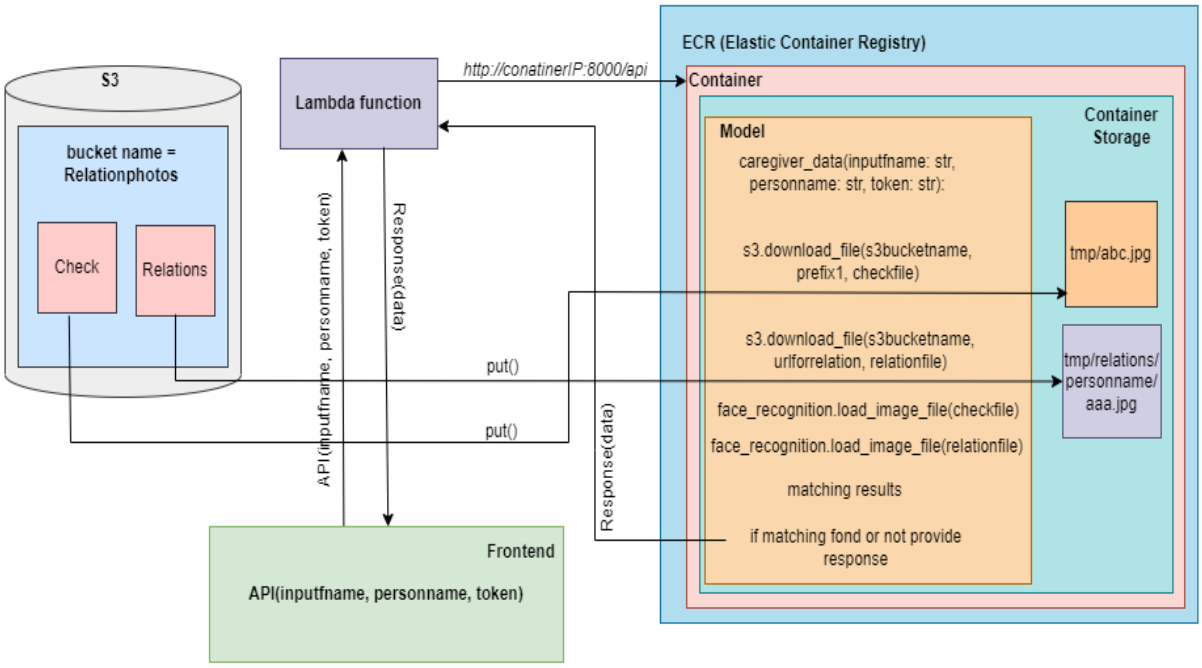


Figure 3.2: In-detail system architecture diagram

In the context of front-end application execution, a complex and orchestrated process unfolds, involving several integral components within a cloud computing environment. Initially, the front-end of the application triggers an API call, serving as the genesis of the computational chain. Subsequently, a Lambda function is activated, commencing the orchestration of operations. This Lambda function, acting as a crucial intermediary, facilitates the transmission of an HTTP request to a container residing within the Amazon Elastic Container Registry (ECR). Within this container, a important phase ensues, wherein a machine learning model is instantiated and set into motion.

One noteworthy facet of this intricate process pertains to data provisioning. Images, critical for subsequent analysis, are sourced from disparate locations within the AWS ecosystem. Images stored within designated Amazon S3 folders are first retrieved,

ensuring that pertinent data is ready. Moreover, images residing in the "relations" folder, a separate repository, are also drawn into the container's storage repository within the ECR. This preparatory step is imperative to establish a robust foundation for subsequent computational tasks.

Following the successful data acquisition, the core computational activities commence. The heart of this operation involves the encoding and comparative analysis of the retrieved images. The machine learning model, situated within the container, embarks on a rigorous process of feature extraction, image encoding, and comparative analysis. This multifaceted analytical task culminates in the generation of responses, which are subsequently relayed to the front-end of the application.

As a summary, this comprehensive sequence of actions underscores the intricacy and orchestration inherent to modern cloud-based application architectures. From API initiation to Lambda function invocation, containerized processing, and data acquisition, to the sophisticated image analysis, each step plays a pivotal role in ensuring the provision of timely and accurate responses to the front-end, underscoring the significance of a well-structured and coordinated cloud computing workflow.

app.py

```
result = []

response = s3.list_objects_v2(Bucket=s3bucketname, Prefix=prefix2)

if "Contents" in response:
    for obj in response["Contents"]:
        if obj["Key"].endswith((".png", ".jpg", ".jpeg")):
            urlforrelation = obj["Key"]

            parsed_url = urlparse(urlforrelation)
            path = parsed_url.path
            directories = path.split("/")

            filename = os.path.basename(path)
            relation_name = directories[-3]
            person_name = directories[-2]
            relation_person = directories[-4]

            relationfile = f"{relations_folder}/{filename}"

            s3.download_file(s3bucketname, urlforrelation, relationfile)

            known_image = face_recognition.load_image_file(checkfile)
            unknown_image = face_recognition.load_image_file(relationfile)

            biden_encoding = face_recognition.face_encodings(known_image)[0]
            unknown_encoding = face_recognition.face_encodings(
                unknown_image
            )[0]

            relcheckresults = face_recognition.compare_faces(
                [biden_encoding], unknown_encoding
            )

            if relcheckresults[0] == True:
                url = s3.generate_presigned_url(
                    "get_object",
```

Figure 3.3.: Face Recognition implementation

3.1.2. Data collection methods.

This research project represents a comprehensive data collection and analysis system, thoughtfully built using a Fast API web application as its core infrastructure. The application's architecture incorporates a synergy of essential technologies and AWS (Amazon Web Services) services to streamline the retrieval and meticulous processing of image data, all tailored to meet the specific requirements of our research objectives.

To ensure secure and authorized access to the system, a robust token-based authentication mechanism has been integrated. This authentication layer guarantees that only authorized users with the correct access key are permitted to initiate data collection and analysis processes.

Upon receiving requests, the system seamlessly interfaces with an Amazon S3 bucket, making use of the Boto3 library to interact with AWS services. This interaction is pivotal in the retrieval of image files, and it intelligently organizes these files into predefined directories within the local environment. This systematic organization enhances the efficiency of subsequent image analysis.

The core of the data collection process is the utilization of the 'face_recognition' library, a powerful tool for facial recognition tasks. The application employs this library to conduct facial recognition on the downloaded images. This involves comparing each acquired image against a reference image, typically referred to as the 'known image.' The 'known image' serves as a baseline for recognizing individuals.

Detected matches during the facial recognition process are meticulously cataloged, capturing various details such as the filenames of the images, URLs pointing to the recognized individuals' photos, and pertinent relationship information. This comprehensive cataloging ensures that the results of the data collection process are well-structured and readily available for further analysis.

The strength of this method lies not only in its efficiency but also in its adaptability. Researchers can easily configure the Amazon S3 bucket to suit their specific research needs, such as adjusting the directory structure or organizing images in a particular way.

Additionally, the recognition parameters can be fine-tuned, allowing the system to be highly versatile and accommodating to various research scenarios. In essence, this data collection and analysis system represents a powerful and flexible tool for data-driven research endeavors, enabling researchers to derive valuable insights from image data with precision and ease.

3.1.3. Tools and Technologies

Tools

- Visual Studio Code
    - To implement the mobile application
- Jupiter Notebook
    - To train the machine learning models
- Docker
    - To create a container image.
- Postman
    - To test the mobile application

Technologies

- Python
- Expo
    - A set of tools and services that makes the app development and build process much better
- React Native
- Mangum
    - Used to deployment on AWS Lambda
- Urllib3
    - Used for making HTTP requests, handling, and managing connection.
- AWS Lambda
    - Used for creating a secure URL communicate between frontend and AWS container
- AWS Amplify
    - Used for uploading images to AWS S3 buckets. That is a framework.
- Fast API
    - To implement the backend API for the mobile application.
- Uvicorn

Table 3.1: External Tools

Description	**Tools**
Version Controlling	Gitlab
Team connectivity	Teams, WhatsApp

3.2. Commercialization aspects of the product

In our pursuit of commercializing our mobile application, which holds immense potential to benefit individuals worldwide, we recognize the need for a multifaceted approach that aligns with current global trends and user behaviors. Given that our application operates in the international language of English, its reach extends far beyond the borders of Sri Lanka, making it accessible and relevant to a global audience. To ensure swift and widespread adoption, we have strategically identified several key avenues for commercialization, with a primary focus on harnessing the immense power of social media platforms.

In today's digital landscape, social media stands out as a dynamic and influential force. With millions of users spending a substantial portion of their daily lives on platforms such as Facebook, WhatsApp, Instagram, and YouTube, leveraging these channels for advertising and promotion is not only prudent but essential. Through targeted and engaging adverts on these platforms, we can effectively introduce our application to a vast and diverse consumer base, transcending geographical boundaries.

Furthermore, we have recognized the importance of content providers in shaping trends and boosting user engagement. Platforms like YouTube, Twitch, and Trovo are home to a growing community of content creators with large followings. By selectively sponsoring and supporting these influencers, we can use their reach and influence to raise awareness about our system within their respective communities. This spontaneous recommendation can help us create confidence and credibility for our application.

To broaden our reach, we intend to work closely with healthcare organizations such as hospitals and clinics. Within their communities, these institutions provide reliable sources of knowledge and care. We can design targeted awareness programs that appeal to both healthcare professionals and patients by collaborating with them. This strategy ensures

that our application reaches people from all walks of life, regardless of financial status.

We recognize the lasting power of conventional media in addition to digital platforms. For example, leaflets can be a useful instrument for increasing public awareness of our product, particularly within rural communities. We also recognize the importance of radio and podcasts, which continue to have a loyal following. Sponsoring radio shows and podcasts that cater to our target audience can be a beneficial outlet for advertising our product and its benefits.

3.3. Testing and Implementation

3.3.1. Implementation

The recommended functionalities and accessibility standards would be given top billing throughout system implementation. Software architectures that allow for seamless communication between parts will be developed. All models will be developed following industry standards and trained on high-quality datasets for maximum accuracy.

Before starting the implementation, a requirement analysis must be done first. Therefore, user requirements functional requirements, and non-functional requirements were gathered as below.

Functional requirements

- Extract data from the image
- Identify the person who is captured.
- Provide a description of the captured person.
- Display the memory with that person.
- Provide voice output of the details that are displayed on the screen.

Non-functional requirements

- Usability
- Accuracy
- Availability
- Compatibility
- Well optimized for cloud/mobile use
- Security

User requirements

- User must have a smartphone with a working camera.
- User must have basic English knowledge
- User should not be severe level dementia patient .
- User should have a simple knowledge to use a mobile application
- User should be able to touch and feel the screen to navigate through the app

For the implementation of face recognition, it has both server-side and client-side implementations, client-side implementations mean the mobile application, and the server-side implementation means the face recognition process. The mobile application implementation is developed using the React Native framework.

```
3
4   @app.get("/api")
5   async def caregiver_data(inputfname: str, personname: str, token: str):
6       key = "RRshJy4beYdlNbu"
7
8       if token == key:
9           logger.info("INFO: Program is Running...")
0
1           s3 = boto3.client(
2               "s3",
3               aws_access_key_id="AKIAXDPKO46TVVL25E4L",
4               aws_secret_access_key="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",
5           )
6
```

Figure 3.4 : Access the AWS S3 bucket.

Boto3 is the AWS Software Development Kit (SDK) for python. It allows developers to interact with various AWS services using python code. It provides an easy way to automate tasks and build applications that leverage AWS resources, all through python programming. Figure 3.4. shown the code that access the AWS S3 bucket by providing access key Id and the secret key.

```
37          s3bucketname = "relationphotos"
38          filenameinput = inputfname
39          s3checkdir = "Check"
40          donwload_folder = "/tmp"
41
42          logger.info("INFO: Input file:" + filenameinput)
43
44          prefix1 = f"{s3checkdir}/{filenameinput}"
45          checkfile = f"{donwload_folder}/{filenameinput}"
46
47          s3.download_file(s3bucketname, prefix1, checkfile)
48
49          if os.path.exists(checkfile):
50              relations_folder = "/tmp/relations"
51
52              if not os.path.exists(relations_folder):
53                  os.makedirs(relations_folder)
54
55              s3relationsdir = "Relations"
56              s3personanem = personname
57              prefix2 = f"{s3relationsdir}/{s3personanem}"
58
59              logger.info("INFO: Input person:" + s3personanem)
60
61              result = []
62
63              response = s3.list_objects_v2(Bucket=s3bucketname, Prefix=prefix2)
```

Figure 3.5: Code snippet of Images storing in S3 bucket.

The provided code snippet(Figure 3.5) is a Python script that interacts with an AWS S3 bucket. It begins by initializing several variables, including the S3 bucket name (`s3bucketname`), an input file name (`filenameinput`), a directory prefix within the S3 bucket (`s3checkdir`), and a local download folder path (`donwload_folder`). A logging message is generated to record the input file name. The code then constructs S3 object prefixes and downloads a file from the S3 bucket to a local file path, checking for its existence. It proceeds to create a local directory (`relations folder`) if it doesn't already

exist. Another S3 object prefix (`prefix2`) is formed, likely representing a directory within the S3 bucket associated with a specific person's name. The script logs this person's name and proceeds to list objects in the S3 bucket under this prefix. Overall, the code appears to be part of a larger application for managing files and data in an S3 bucket, with additional functionality beyond this snippet.

```
parsed_url = urlparse(urlforrelation)
path = parsed_url.path
directories = path.split("/")

filename = os.path.basename(path)
relation_name = directories[-3]
person_name = directories[-2]
relation_person = directories[-4]

relationfile = f"{relations_folder}/{filename}"

s3.download_file(s3bucketname, urlforrelation, relationfile)

known_image = face_recognition.load_image_file(checkfile)
unknown_image = face_recognition.load_image_file(relationfile)

biden_encoding = face_recognition.face_encodings(known_image)[0]
unknown_encoding = face_recognition.face_encodings(
    unknown_image
)[0]

relcheckresults = face_recognition.compare_faces(
    [biden_encoding], unknown_encoding
)
```

Figure 3.6 : face detection and face encoding

Above code snippet (Figure 3.6) about the face detection and face encoding. The face detection algorithm looks through the image and finds areas where faces are probably to be present. Once faces are detected, the library extracts facial features from the detected faces. It uses a deep neural network to generate a numerical representation, called face encoding or face embedding, for each face. This encoding captures unique characteristics and patterns of the face. To perform face recognition, the system compares the face

encodings of the detected faces with the encodings of known faces stored in a S3 bucket.

For the feasibility study regarding the implementation, below mentioned feasibility studies are done in the development process. Scheduled feasibility, technical feasibility and economy feasibility features are described in thee below description

Schedule Feasibility:
The proposed system must adhere to the specified timeline to deliver a high-quality product. To ensure quality, each phase should have defined time constraints, which will be visually represented in the Gantt chart for each task.

Technical Feasibility:
Research team members are expected to possess a foundational understanding of mobile application development technologies and machine learning methods. To successfully contribute to the suggested application, it is essential for all team members to have knowledge of computer programming languages for implementation purposes.

Economy feasibility:
Cost constraints should be applied to the allocation of resources for the product. All team members should work within the specified budgetary limits. The approach should prioritize cost-effectiveness while maintaining a comprehensive scope.

3.3.2. Testing

Due to the critical importance of early flaw detection and issue resolution in the application's life cycle, a diverse array of testing methodologies will be employed to rigorously assess the product.

The release of the product should be scheduled only after an exhaustive and meticulous testing phase has been successfully conducted, ensuring that every conceivable aspect, feature, and functionality has been rigorously examined, evaluated, and validated. Furthermore, any issues, glitches, or anomalies identified during this comprehensive testing process must be thoroughly and promptly addressed, resolved, and rectified to guarantee a flawless and trouble-free product release that meets the highest standards of quality and reliability.

Unit testing, integration testing, and user acceptability testing are just a few of the approaches that will be used to ensure the quality of the final product. In order to catch bugs and problems early in the development of an application, thorough testing is required. Any problems found during testing will be fixed as soon as possible so that the final product can be released without any obstacles.

Some of the test cases used to test the product are included below, along with screenshots.

Table 3.2 : Test cases for face recognition page.

Test Case #	**Test case**	**Result**
001	Camera opens from the open camera button	Pass
002	All the buttons and widgets are visible	Pass
003	Navigate for pages through buttons	Pass
004	Image successfully captured after opening the camera	Pass
006	After capturing the image navigate to the next page	Pass
007	After press the save button give success alert	Pass
008	Load the name and relationship	Pass
009	Load the memory images	Pass
010	After press the sound button gives the voice output	Pass
011	Proper page alignment	Pass
012	Proper words with correct spellings	Pass

Table 3.3 : Test cases add memory page

Test Case #	Test case	Result
001	Camera opens from the Add memory button	Pass
002	All the buttons and widgets are visible	Pass
003	Navigate for pages through buttons	Pass
004	Access the phone gallery when press the pick image from gallery button.	Pass
005	Image successfully captured after opening the camera	Pass
006	After capturing the image navigate to the next page	Pass
007	Navigate to the camera page after press the re-take button	Pass
008	Load the text fields for type name and relationship.	Pass
009	When selecting the 'pick image ' navigate to the phone gallery.	Pass
010	User able to choose multiple images	Pass
011	After press the save button give success alert	Pass
012	Proper page alignment	Pass
013	Display words with correct spellings	Pass

Above table shows the test cases done for image interpretation. Also, this application was tested by using three different end users and table 3.4 shows the results of it. For that we contacted two people with mild and moderate level dementia. Those people are respectively named in the table as User 3, User 2 and User 1.

Table 3.4 : Test cases done by end users

Test Case #	Test case	User 1	User 2	User 3
001	Open the mobile application without any error	Opened the application without any issue	Opened the application without any issue	Opened the application without any issue
002	Camera opens from the open camera button	Able to open the camera with the guidance of voice assistant	Able to open the camera from the camera button	Able to open the camera from the camera button
003	Navigate for pages through buttons	Navigated through all the pages	Navigated through all the pages	Navigated through all the pages
004	Able to capture the photo successfully	Captured the image without any issue	Captured the image without any issue	Captured the image without any issue
005	Display the data of the captured photo of the person	Display without any issue.	Display without any issue.	Display without any issue.
006	Provide voice output of the displayed data	Provide without any issue.	Provide without any issue.	Provide without any issue.

Finally, to complete the testing process we tested out application with different OS versions with different kind of android devices. The test cases for that are shown below in table 3.5.

Table 3.5 : Test cases for devises with different OS

Test Case #	**Device**	**OS**	**Version issues**	**Issues with the interfaces**
001	Oppo A9 2020	Android 9	No issues	No issues
002	Redmi C12	Android 13	No issues	No issues
003	Samsung galaxy grand prime	Android 5	No issues	No issues

4. RESULTS AND DISCUSSION

4.1. Results

The face recognition system works using a live training mechanism. Therefore, there no limit for the faces that can be identified. It displays name and the relationship for captured photo that are useful enough for dementia patients to identify person. In figure 4.1.1 shows the postman request for the created API.

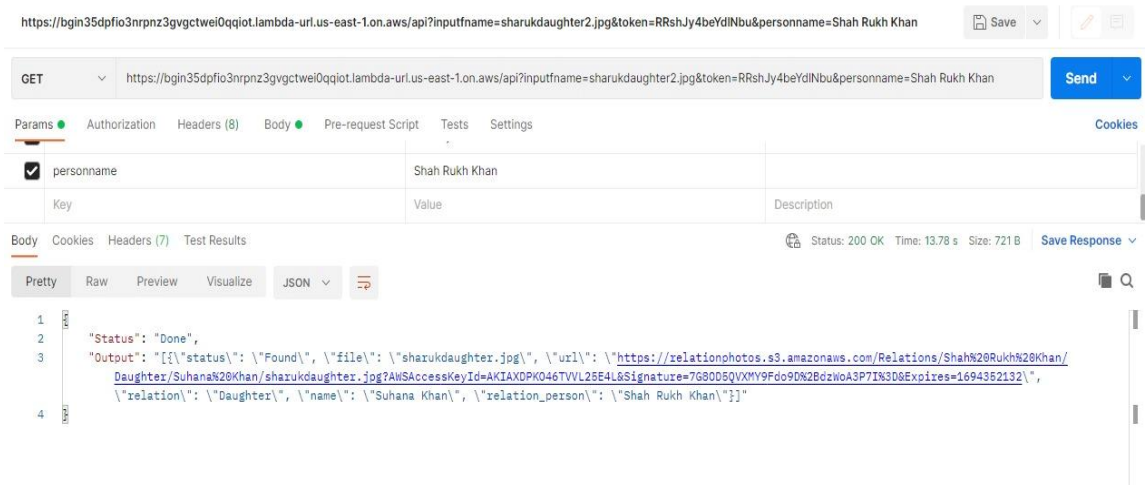


Figure 4.1: Postman GET request

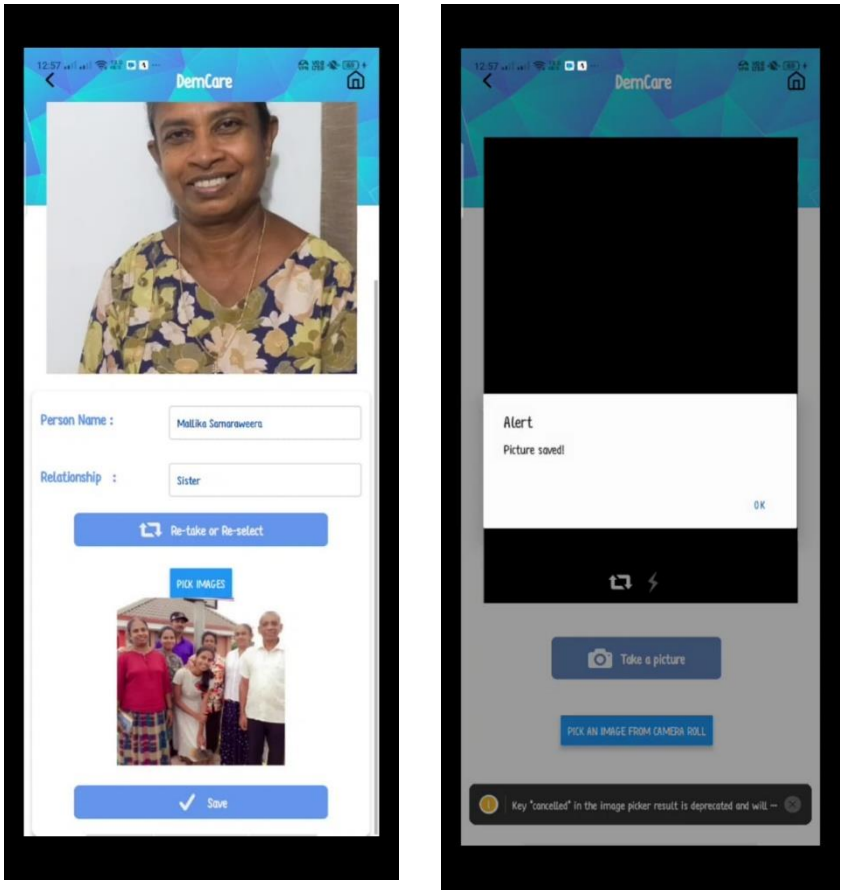


Figure 4.2: Add the people to the system (Caregiver Part).

After pressing the “save” button it displays the success alert shown in figure 4.2.

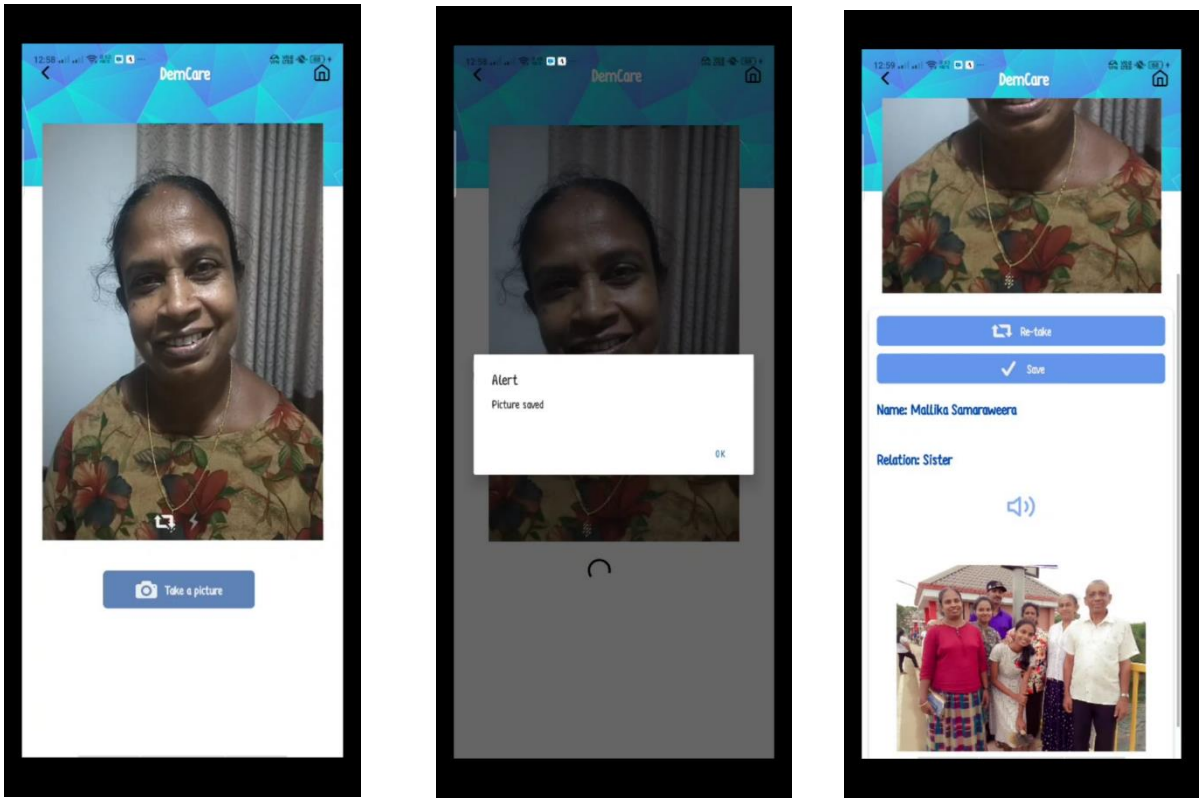


Figure 4.3 : Identified the faces.

Figure 4.3 shows result that are displayed in the implemented face recognition component. As you can see, the name and the relationship are displayed correctly. So, it is clearly shown that the implemented mobile application gives a high accurate result and the capability of identifying faces.

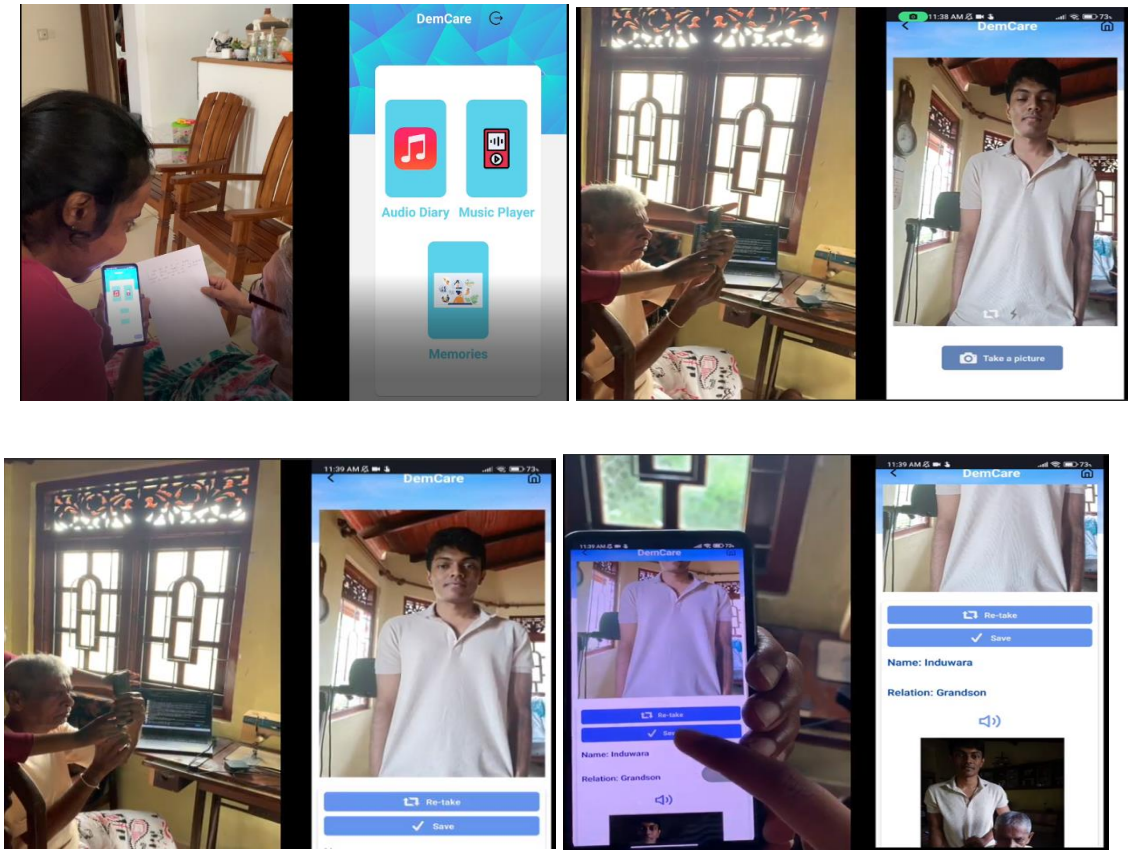


Figure 4.4: Sample image tested with dementia patient.

Our team was founded a mild level male dementia patient around 75 years old. Therefore, we got the chance to test and get feedback on the implemented solution. He tested the application with his grandson. In figure 4.4 shows the snapshots that were taken on that day.

4.2. Research Findings

This research project has a primary focus on the development of a dedicated mobile application designed to assist in identifying relatives and family friends of individuals living with dementia. Notably, there is a significant gap in existing research that addresses this aspect of dementia care. While various mediums have been explored to aid dementia patients, they often encounter numerous obstacles that remain unaddressed.

The principal objective of this study is to harness the power of neural network techniques, specifically through mobile applications, to enhance the independence and overall quality of life for individuals with mild to moderate dementia. By leveraging the capabilities of neural networks, this application aims to provide valuable support and assistance to this demographic.

One noteworthy achievement of this research is the remarkable accuracy achieved by the implemented system, which surpasses an impressive 99.38%. This outstanding level of accuracy ensures that the system can reliably and consistently identify individuals' faces, marking a significant advancement in face recognition technology.

The successful implementation of this face recognition system owes much to the utilization of various Python libraries and cutting-edge deep learning techniques. Convolutional neural networks and other contemporary deep learning algorithms have played a pivotal role in driving the effectiveness of this system, demonstrating their versatility and applicability in various domains, including dementia care.

In conclusion, this research endeavor holds the potential to substantially enhance the independence and quality of life for individuals with mild to moderate dementia. By harnessing the power of neural networks and face recognition technology, this mobile application serves as a promising tool in addressing the unique challenges faced by dementia patients and their caregivers.

4.3. Discussion

Throughout the course of our research on dementia patients, several crucial factors emerged during the development and testing phases. To gain a comprehensive understanding of the dementia patient population, we initially delved into existing research. Our literature review encompassed extensive data from global dementia databases, comprising population-based studies that detailed the prevalence of dementia across different age groups. Furthermore, we gathered information on age-specific dementia prevalence rates and the total number of individuals affected by dementia within specific age brackets.

Building on this foundation, we recognized the need for firsthand insights into the experiences and challenges faced by dementia patients and their caregivers. Subsequently, we embarked on an effort to collect critical research data directly from those affected. To achieve this, we conducted an online survey tailored to the unique needs and perspectives of dementia patients and their caregivers. This survey was efficiently administered through the distribution of a user-friendly Google Form, facilitating the gathering of valuable insights and experiences from the dementia community.

Initially, implement a solution that has the capability to detect familiar faces. Then the features of the detected faces are extracted using deep neural network technologies like face encoding. Finally, computes the similarity between the face encodings using distance metrics such as Euclidean distance . A threshold value is usually set to determine whether two face encodings are considered a match. Based on the computed similarities, the system can identify known faces by finding the closest match(es) to the detected face(s) in the list of known faces.

In the testing process, there are a few things that should be implemented. The quality of the user interfaces which are suitable for elderly dementia patients..

Also, we have to check the image capturing using flash button option in low -light environment, but so far the current capturing result of faces gives a considerable output which satisfied the dementia patient. The face will be captured from the mobile device by the user initially. And then the image stored in the AWS S3 bucket. Then those stored images get downloaded inside the container storage in the AWS Elastic Container Registry. The photos will go through the several technologies such as neural network algorithms, deep neural network and then system send to the appropriate response to the frontend. Following the completion of the analysis, name and relationship will be prompted. Additionally, it gives the voice output and memory slides to recall the patient memories.

4.4. Summary of student contribution

Student: Madhubhashini A.D.P. – IT20174576

Research component: Design a smart solution that have capability to detect patients loved ones and relatives via face recognition in a way that patient is fully independent.

Task: This component is designed to develop a face recognition system integrated into the application. Its inputs include images containing human faces, and the output will identify and provide descriptions of the recognized faces.

Tasks completed:

- Developed the mobile application
- Implemented the backend with Fast API to get the face recognition services by the application.
- Implemented the face recognition model.
- Implement text to speech library to the application to get the voice output.

5. CONCLUSION

In conclusion, dementia presents a formidable challenge, impacting individuals' ability to carry out daily activities and recognize familiar faces. The vulnerability of this population, especially when lacking proper support, underscores the urgency for innovative solutions.

Our research aims to enhance interaction and quality of life for individuals with dementia. Further studies in clinical settings can assess the effectiveness of this innovative approach, offering hope for improved care and support for dementia patients and their families.
Central to our solution is the integration of cutting-edge technologies, including a convolutional neural network (CNN) and a deep neural network-based facial recognition system. These technologies, seamlessly incorporated with a smartphone camera and person description feature, offer a promising avenue to enhance the quality of life and interactions of individuals living with dementia.These studies will provide valuable insights into its real-world impact and potential benefits.

As a summary, our research represents a crucial step toward addressing the challenges faced by dementia patients and their families. By bridging the gap between technology and dementia care, we aspire to make a meaningful difference in the lives of those affected by this condition, promoting a more supportive and compassionate approach to dementia care within our society.

REFERENCES

[1] Institute of Electrical and Electronics Engineers, *2015 International Conference on Information Networking (ICOIN) : date, 12-14 Jan. 2015.*

[2] P. Riley, N. Alm, and A. Newell, "An interactive tool to promote musical creativity in people with dementia," *Comput Human Behav*, vol. 25, no. 3, pp. 599–608, May 2009, doi: 10.1016/j.chb.2008.08.014.

[3] N. Aljojo *et al.*, "Alzheimer assistant: a mobile application using Machine Learning," *Revista Română de Informatică și Automatică*, vol. 30, no. 4, pp. 7–26, Dec. 2020, doi: 10.33436/v30i4y202001.

[4] Sadjad University of Technology, Institute of Electrical and Electronics Engineers. Iran Section., and Institute of Electrical and Electronics Engineers, *ICEE 2018 : 2018 26th Iranian Conference on Electrical Engineering : Sadjad University of Technology, 8-10 May 2018.*

[5] IEEE Staff and IEEE Staff, *2010 32nd Annual International Conference of the IEEE Engineering in Medicine and Biology Society.*

[6] H. M. Fardoun, A. A. Mashat, and J. Ramirez Castillo, "Recognition of familiar people with a mobile cloud architecture for Alzheimer patients," Disabil Rehabil, vol. 39, no. 4, pp. 398–402, Feb. 2017, doi: 10.3109/09638288.2015.1025992

[7] "SwiftFace:Real-TimeFaceDetection." https://www.researchgate.net/publication/344422660_SwiftFace_Real-Time_Face_Detection (accessed Mar. 20, 2023).

[8] S. Lee-Cheong, S. Amanullah, and M. Jardine, “New assistive technologies in dementia and mild cognitive impairment care: A PubMed review,” *Asian J Psychiatr*, vol. 73, p. 103135, Jul. 2022, doi: 10.1016/J.AJP.2022.103135.

[9] R. Yamashita, M. Nishio, R. K. G. Do, and K. Togashi, “Convolutional neural networks: an overview and application in radiology,” *Insights Imaging*, vol. 9, no. 4, pp. 611–629, Aug. 2018, doi: 10.1007/S13244-018-0639-9/FIGURES/15.

[10] M. M. Kasar, D. Bhattacharyya, and T. H. Kim, “Face recognition using neural network: A review,” *International Journal of Security and its Applications*, vol. 10, no. 3, pp. 81–100, 2016, doi: 10.14257/ijsia.2016.10.3.08.

[11] M. Zhou, K. Sabran, and Z. Ahmad Zahari, “Designing User Interface for People with Dementia: A Systematic Literature Review,” Apr. 2022. doi: 10.4108/eai.24-8-2021.2315094.

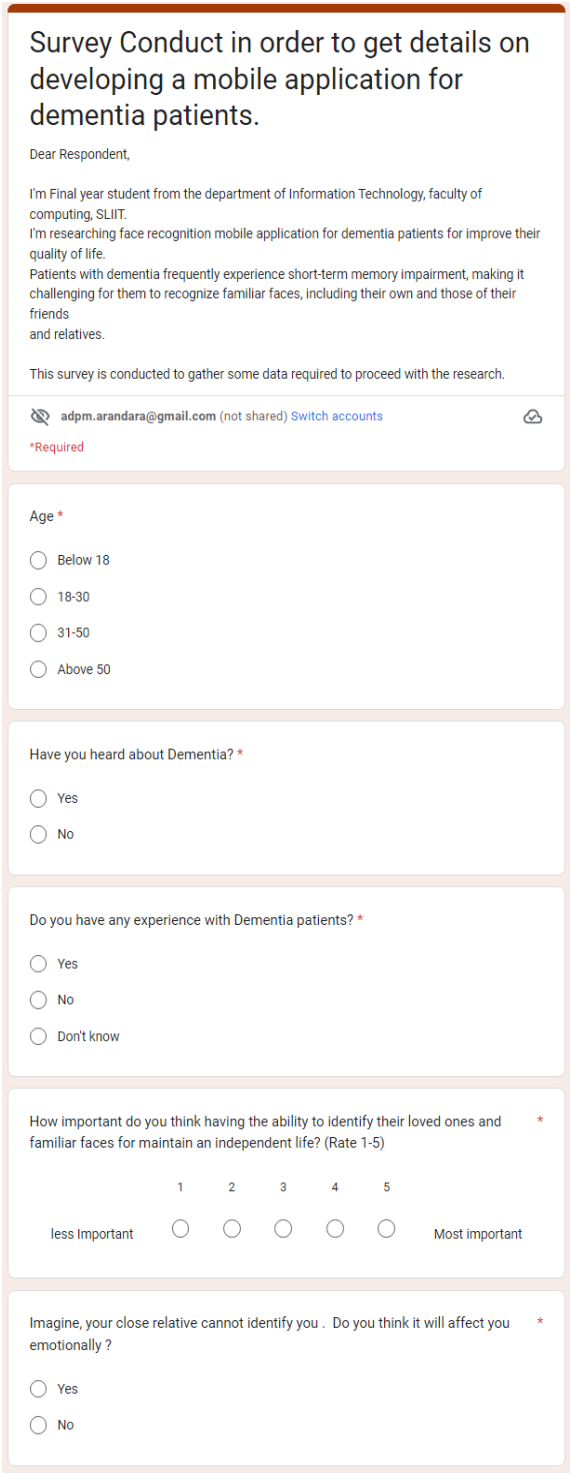
[12] H. Ning, R. Li, X. Ye, Y. Zhang, and L. Liu, “A Review on Serious Games for Dementia Care in Ageing Societies,” *IEEE J Transl Eng Health Med*, vol. 8, 2020, doi: 10.1109/JTEHM.2020.2998055.

[13] S. A. Schultz *et al.*, “Participation in cognitively-stimulating activities is associated with brain structure and cognitive function in preclinical Alzheimer’s disease,” *Brain Imaging Behav*, vol. 9, no. 4, p. 729, Dec. 2015, doi: 10.1007/S11682-014-9329-5.

[14] K. A. Mcdonnell, “Favorite Faces App: Design and Review of a Mobile App Prototype to Help Improve FaceName Recognition for those with Early to Moderate Stage Dementia Item Type Thesis.” [Online]. Available: http://hdl.handle.net/20.500.12648/915

APPENDICES

Appendix A: Online Survey



Survey Conduct in order to get details on developing a mobile application for dementia patients.

Dear Respondent,

I'm Final year student from the department of Information Technology, faculty of computing, SLIIT.
I'm researching face recognition mobile application for dementia patients for improve their quality of life.
Patients with dementia frequently experience short-term memory impairment, making it challenging for them to recognize familiar faces, including their own and those of their friends
and relatives.

This survey is conducted to gather some data required to proceed with the research.

adpm.arandara@gmail.com (not shared) Switch accounts

*Required

Age *
- Below 18
- 18-30
- 31-50
- Above 50

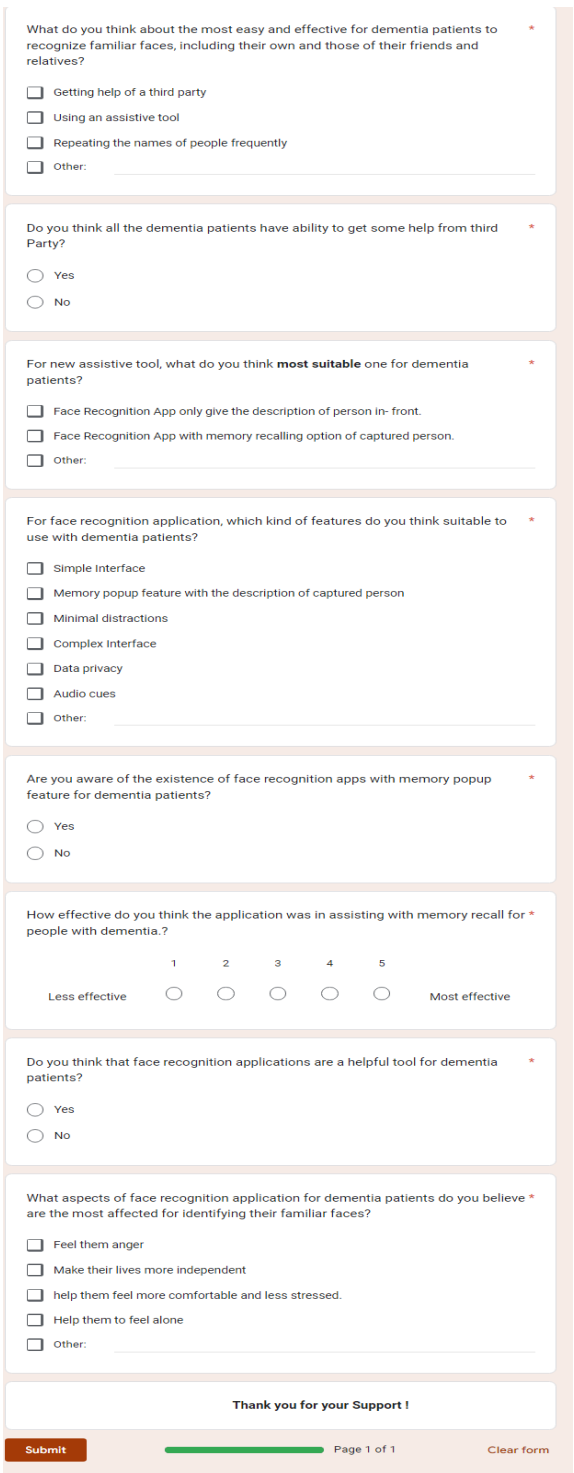
Have you heard about Dementia? *
- Yes
- No

Do you have any experience with Dementia patients? *
- Yes
- No
- Don't know

How important do you think having the ability to identify their loved ones and familiar faces for maintain an independent life? (Rate 1-5) *

	1	2	3	4	5	
less Important	○	○	○	○	○	Most important

Imagine, your close relative cannot identify you . Do you think it will affect you emotionally ? *
- Yes
- No



What do you think about the most easy and effective for dementia patients to recognize familiar faces, including their own and those of their friends and relatives? *
- Getting help of a third party
- Using an assistive tool
- Repeating the names of people frequently
- Other:

Do you think all the dementia patients have ability to get some help from third Party? *
- Yes
- No

For new assistive tool, what do you think **most suitable** one for dementia patients? *
- Face Recognition App only give the description of person in- front.
- Face Recognition App with memory recalling option of captured person.
- Other:

For face recognition application, which kind of features do you think suitable to use with dementia patients? *
- Simple Interface
- Memory popup feature with the description of captured person
- Minimal distractions
- Complex Interface
- Data privacy
- Audio cues
- Other:

Are you aware of the existence of face recognition apps with memory popup feature for dementia patients? *
- Yes
- No

How effective do you think the application was in assisting with memory recall for people with dementia.? *

	1	2	3	4	5	
Less effective	○	○	○	○	○	Most effective

Do you think that face recognition applications are a helpful tool for dementia patients? *
- Yes
- No

What aspects of face recognition application for dementia patients do you believe are the most affected for identifying their familiar faces? *
- Feel them anger
- Make their lives more independent
- help them feel more comfortable and less stressed.
- Help them to feel alone
- Other:

Thank you for your Support !

Submit — Page 1 of 1 — Clear form

Appendix B: Gantt Chart

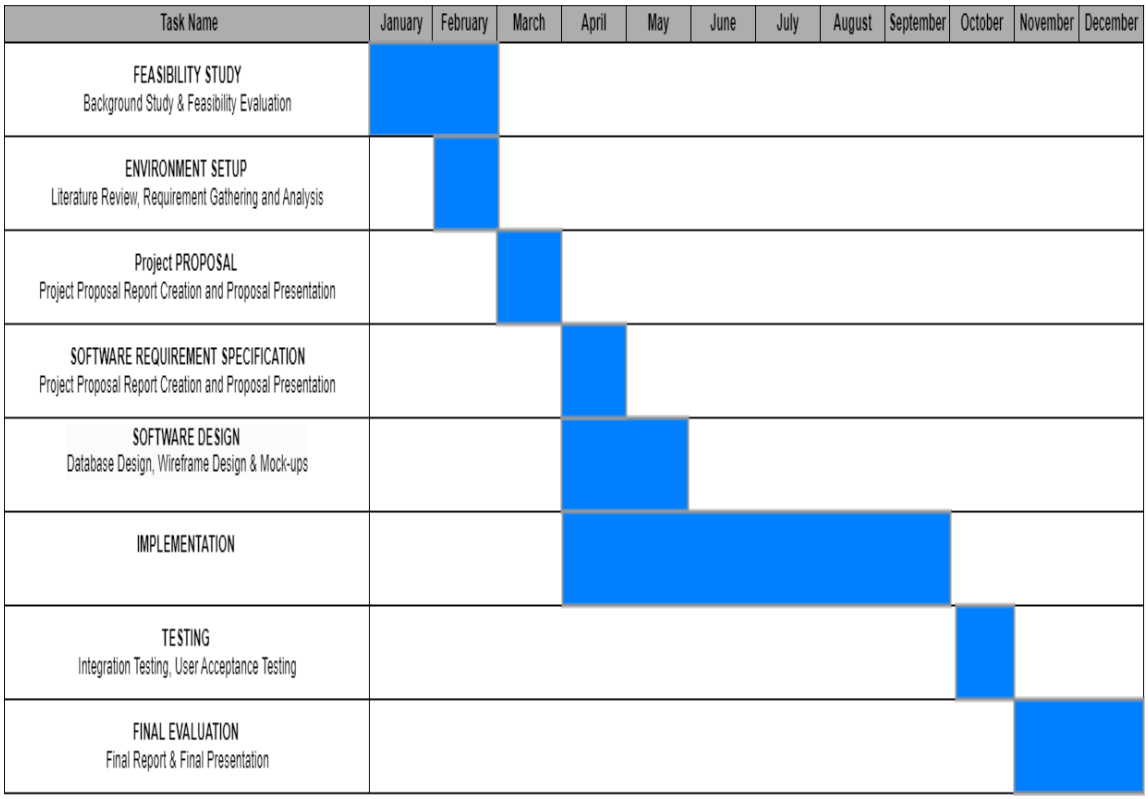


Figure 5.2:Gantt chart

Appendix C: Work Breakdown Structure

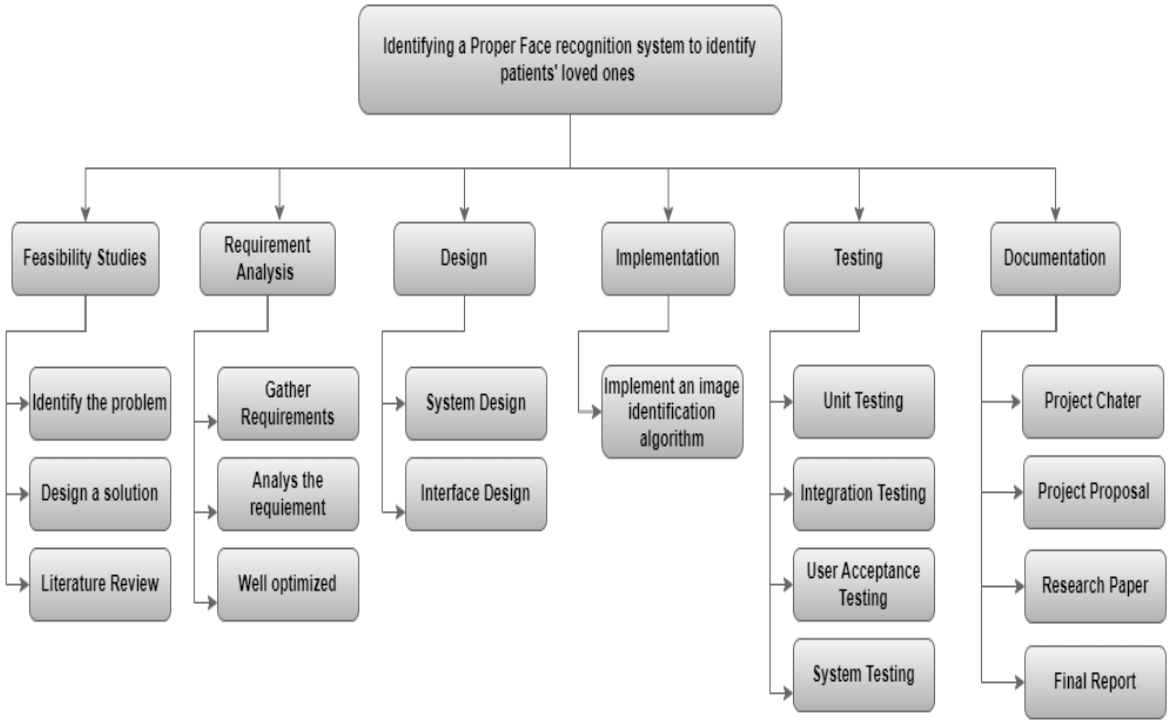
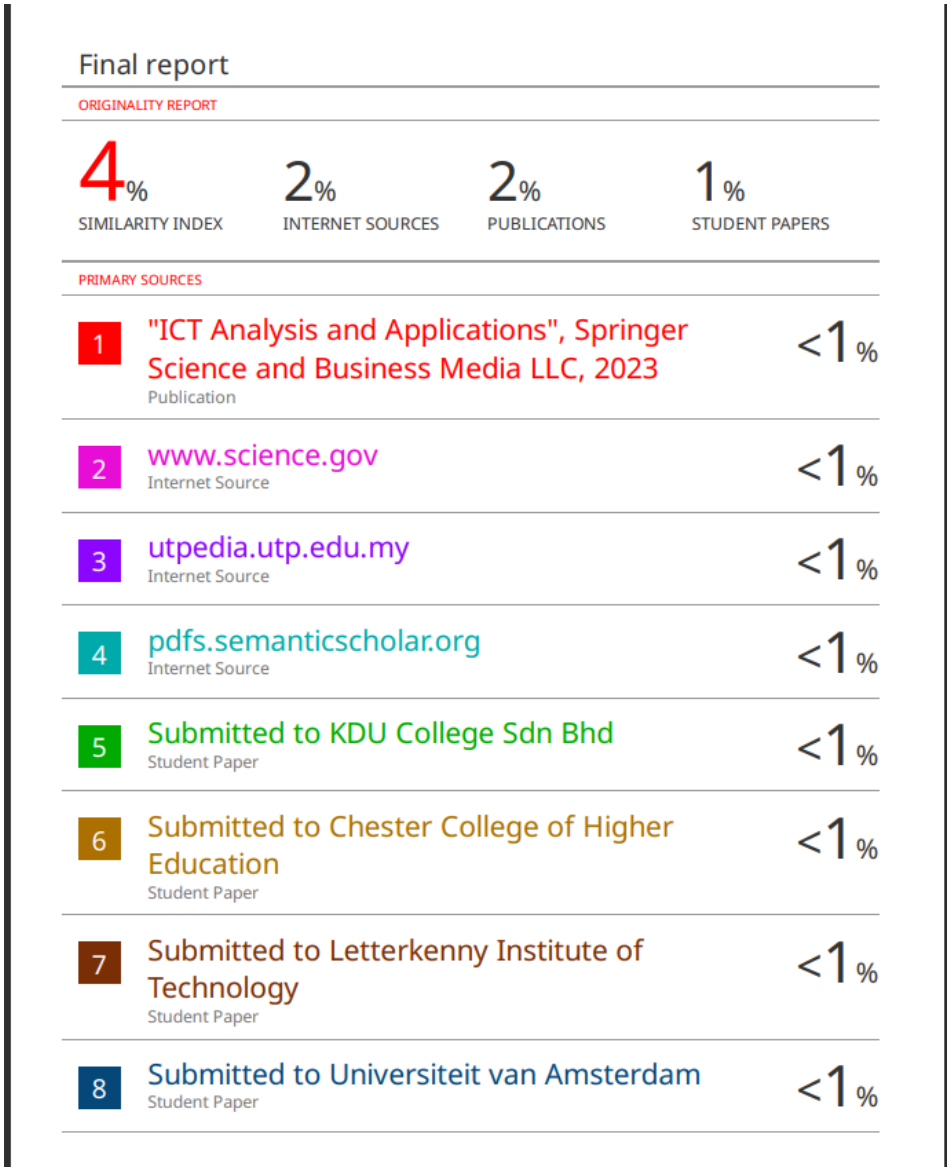


Figure 5.3: Work Breakdown Structure

Appendix D: Plagiarism report



Final report

ORIGINALITY REPORT

4%	2%	2%	1%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	"ICT Analysis and Applications", Springer Science and Business Media LLC, 2023 Publication	<1%
2	www.science.gov Internet Source	<1%
3	utpedia.utp.edu.my Internet Source	<1%
4	pdfs.semanticscholar.org Internet Source	<1%
5	Submitted to KDU College Sdn Bhd Student Paper	<1%
6	Submitted to Chester College of Higher Education Student Paper	<1%
7	Submitted to Letterkenny Institute of Technology Student Paper	<1%
8	Submitted to Universiteit van Amsterdam Student Paper	<1%